

Other tornadoes on August 20, 1911.

The Antler storm was the most destructive of several tornadoes experienced in Bottineau County between 5:30 and 6:30 p. m. on the same day. At least 6 different funnel-shaped clouds formed within the single tornadic area as it passed over this county. Three were reported as being seen from Antler and 6 funnel clouds are reported as having been plainly visible from Souris, 27 miles east and 5 miles south of Antler. Serious damage was reported from but one of these funnels, viz, one which appeared 4 miles southwest of Souris, where it destroyed one farmstead, killing one man and injuring several others. After moving along the ground for but a short distance the funnel rose into the overhanging cloud and disappeared, but reappeared again for a short time as it approached the slope of the Turtle "Mountains" 6 miles to the east.

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SOME RESEARCHES IN THE FAR EASTERN SEASONAL CORRELATIONS.¹

(SECOND NOTE.)

By T. OKADA.

[Reprinted from Journal of the Royal Meteorological Society of Japan, May, 1917, 36:41-49.]

1. *Correlation between the July temperatures at San Francisco, Cal., and Erimo in northern Japan.*—It is a well-known fact that in the summer season the North Pacific HIGH area is a controlling agent of the air temperature on both sides of the North Pacific. A slight shifting to the westward of this action-center gives temperatures below the normal on the western coast of the United States, and the eastward shifting of the HIGH area gives abnormally low temperatures on the eastern coast of northern Japan.

An opposition is traced between the July temperatures (x, y) at San Francisco in California and Erimo in Hokaido. We give below the July temperatures and departures ($\Delta x, \Delta y$), etc., at both stations.

TABLE 1.—July temperatures at San Francisco and Erimo.

[x in the second column means the air temperature at San Francisco, and y in the third column that at Erimo.]

Year.	x	y	Δx	Δy	$\Delta x \Delta y$	$(\Delta x)^2$	$(\Delta y)^2$
	°C.	°C.					
1890.....	15.4	15.9	+1.1	+0.9	+0.99	1.21	0.81
1891.....	15.2	15.8	+0.9	+0.8	+0.72	0.81	0.64
1892.....	14.5	17.8	+0.2	+2.8	+0.56	0.04	7.84
1893.....	13.7	13.8	-0.6	-1.2	+0.72	0.36	1.44
1894.....	13.6	16.5	-0.7	+1.5	-1.05	0.49	2.25
1895.....	14.7	15.3	+0.4	+0.3	+0.12	0.16	0.09
1896.....	15.2	14.9	+0.9	-0.1	-0.09	0.81	0.01
1897.....	14.6	14.0	+0.3	-1.0	-0.30	0.09	1.00
1898.....	13.4	15.1	-0.9	+1.0	-0.09	0.81	0.01
1899.....	13.3	16.9	-1.0	+1.9	-1.90	1.00	3.61
1900.....	14.6	13.6	+0.3	-1.4	-0.42	0.09	1.96
1901.....	13.1	16.0	-1.2	+1.0	-1.20	1.44	1.00
1902.....	15.1	14.0	+0.8	-1.0	-0.80	0.64	1.00
1903.....	14.0	14.2	-0.3	-0.8	+0.24	0.09	0.64
1904.....	13.9	15.9	-0.4	+0.9	-0.36	0.16	0.81
1905.....	15.3	14.5	+1.0	-0.5	-0.50	1.00	0.25
1906.....	14.2	15.6	-0.1	+1.6	-0.16	0.01	2.56
1907.....	14.4	14.0	+0.1	-1.0	-0.10	0.01	1.00
1908.....	14.1	13.5	-0.2	-1.5	+0.30	0.04	2.25
1909.....	14.3	14.5	+0.0	-0.5	+0.00	0.00	0.25
1910.....	13.6	15.0	-0.7	+0.0	+0.00	0.49	0.00
1911.....	13.6	16.5	-0.7	+1.5	-1.05	0.49	2.25
1912.....	14.4	14.1	+0.1	-0.9	-0.09	0.01	0.81
1913.....	15.9	13.1	+1.6	-1.9	-3.04	2.56	3.61
1914.....	13.9	14.6	-0.4	-0.4	+0.16	0.16	0.16
Means.....	14.3	15.0					
Sums.....					-7.34	12.97	35.25

¹ The previous paper (first note) appeared in this REVIEW, January, 1916, 44: 17-21.—
EDITOR.

The temperature data for Erimo have been taken from the Annual Reports of the Central Meteorological Observatory, Tokyo. The daily mean temperature has been calculated from the 6 daily observations, and approximates very closely the true mean temperature. The San Francisco data have been extracted from Prof. A. G. McAdie's "Climatology of California" and the Annual Reports of Chief of the Weather Bureau (4th edition). The mean temperatures at San Francisco given in Table 1 are the sum of the mean maximum and mean minimum temperatures divided by two, and are not reduced to the true mean temperatures as Hofrat Prof. J. von Hann² already remarked. Von Hann has given a small table of corrections to be applied to the many-years' means to reduce them to the true monthly means. But it must be remarked that generally the corrections are different from year to year. Hence the San Francisco temperatures given in the above table differ from the true monthly means, and the difference from the true mean temperature is different year for year. This is specially the case when a secular variation having an amplitude of the order of magnitude comparable to that of the variation under consideration, is superposed on the latter. In such a case the usual method for calculating the correlation coefficient gives an unduly small value.

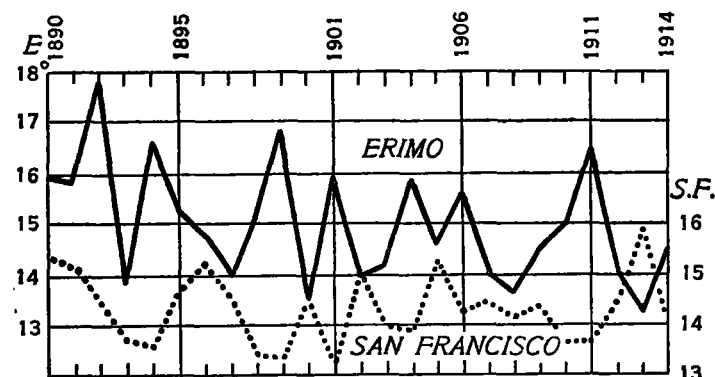


FIG. 1.—Graphic presentation of the fluctuations in the July temperatures at San Francisco, Cal., and Erimo, Hokaido, Japan, 1890-1914, inclusive.

From figure 1, which shows the above data in graphic form, we see that there is a well-established correlation between the July temperatures at San Francisco and Erimo; and the abnormally high temperature on the California coast is associated with abnormally low temperature of this [Japanese] shore of the Pacific.

But the correlation coefficient deduced from the data given in Table 1, is -0.34 and the probable error ± 0.119 . These values are simply suggestive of a connection between the July temperatures on both sides of the Pacific, but they are far from being conclusive of the connection. This apparent discrepancy between the conclusions arrived at by the graphic representation and the calculation, arises from the fact that the fundamental assumption for the calculation of a correlation coefficient is not fulfilled in the present case; that is to say, some unknown variations are superposed on the variation under consideration. Hence it will be rather advisable to compare the variation of temperatures year for year instead of the temperatures themselves. We give in Table 2 the variations of the July temperatures at San Francisco and Erimo. In this table δx means the varia-

² J. von Hann. Klimatologie von Kalifornien. Meteorol. Zeit., 1907, 455.
A. G. McAdie. Die wahre Mitteltemperatur von San Francisco, Kalifornien. Meteorol. Zeit., 1908, p. 330.

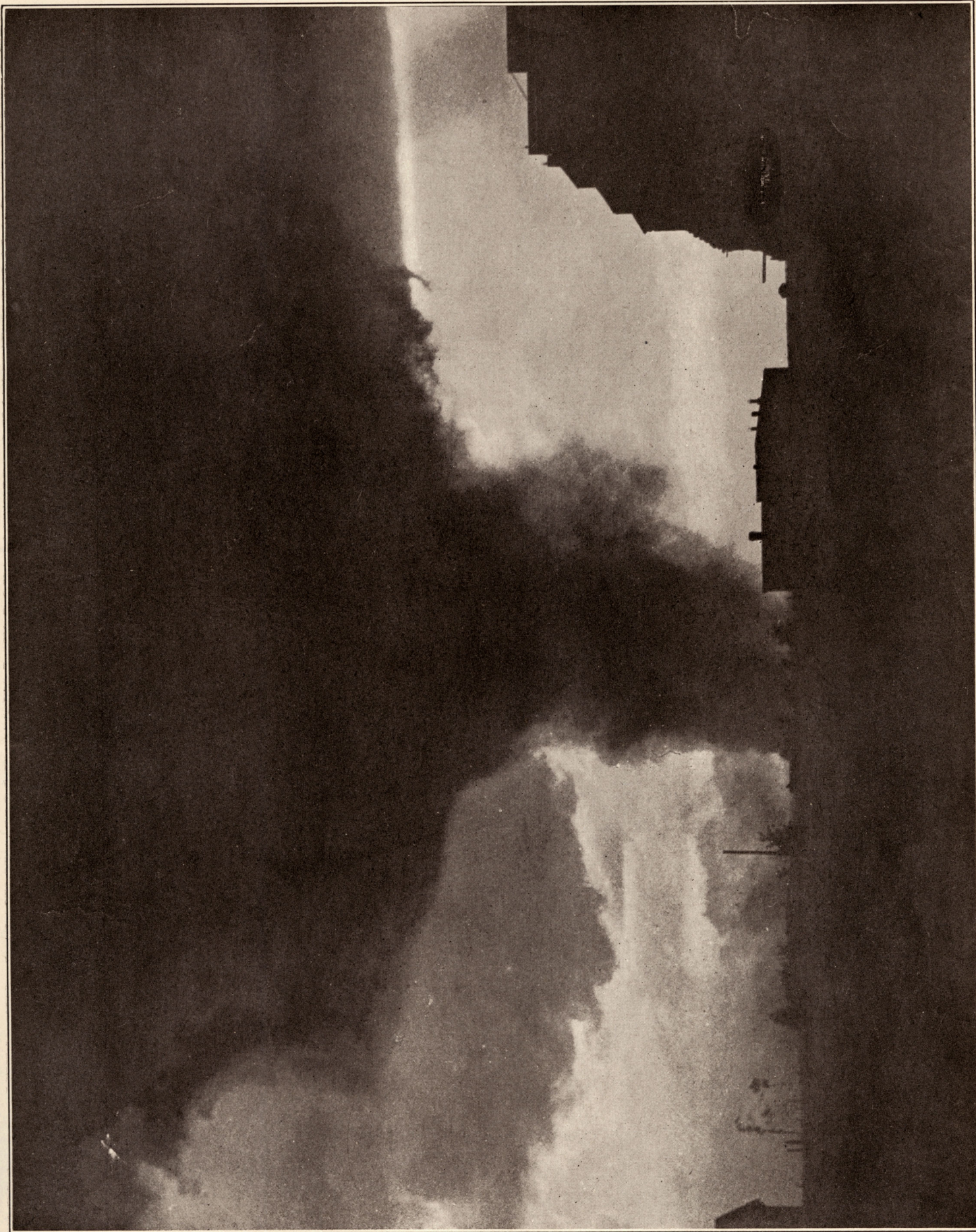


FIG. 1.—The Antler, N. Dak., tornado of August 20, 1911, looking west from Antler, distant $1\frac{1}{2}$ miles. Enlarged from original of figure 4. Photograph by W. H. Wegner, Antler, N. Dak.

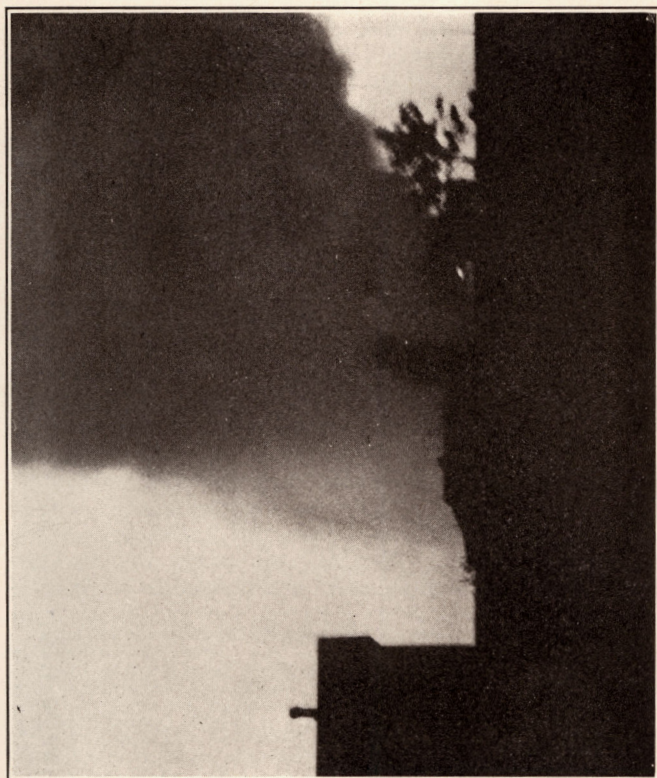


Fig. 2.—The Antler, N. Dak., tornado, looking west-northwest from Antler, distant 1 mile.

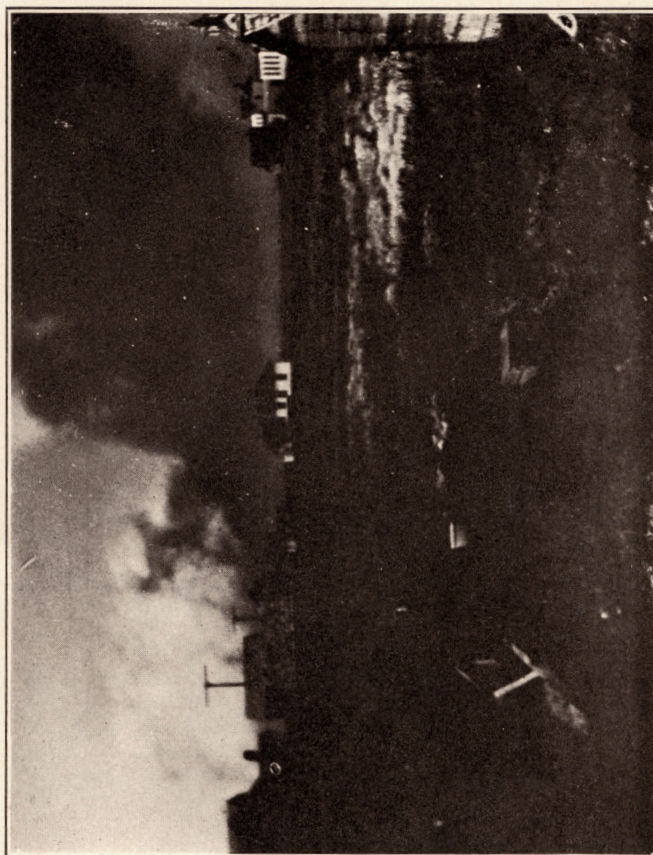


Fig. 3.—The Antler, N. Dak., tornado, looking north from Antler, distant 2 miles.

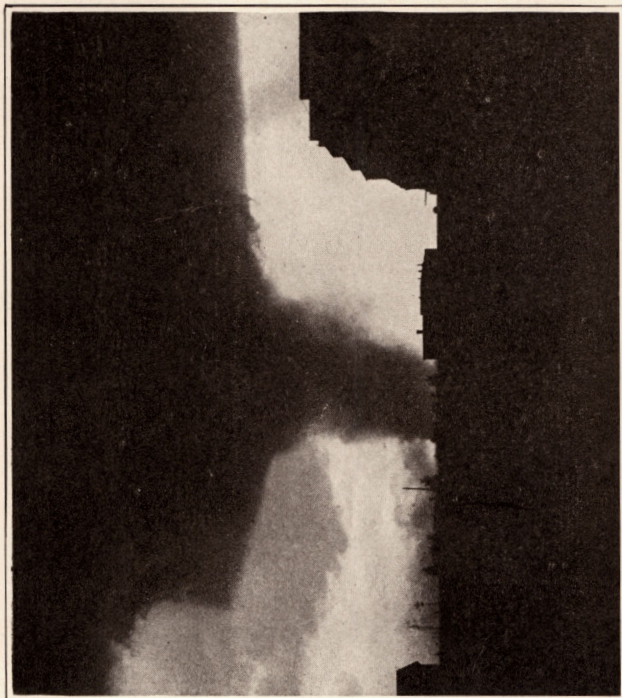
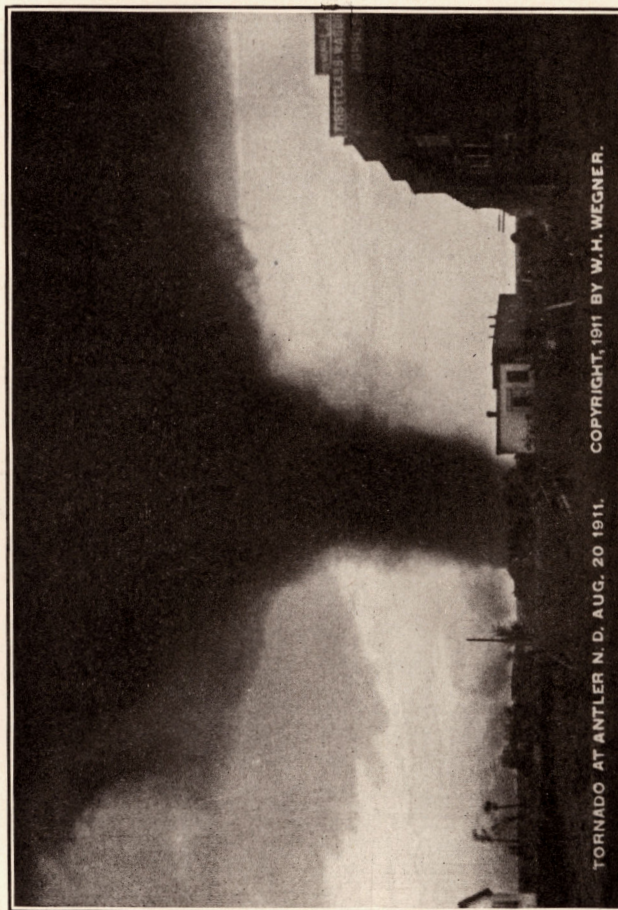


Fig. 4.—View of figure 1 on original scale, from a somewhat lighter print. The original print reveals some of the inner details of the funnel.



TORNADO AT ANTLER N. D. AUG. 20 1911. COPYRIGHT, 1911 BY W.H. WEGNER.

Fig. 5.—The Antler, N. Dak., tornado. Photograph in figure 4 enlarged and double printed, without retouching, with later photograph of identical foreground.

tions of the San Francisco temperatures and δy those of the Erimo temperatures.³

TABLE 2.—Correlation of variations of July temperatures at San Francisco (δx) and Erimo (δy).

Year.	x	y	Variations.				
			δx	δy	$\delta x \delta y$	$(\delta x)^2$	$(\delta y)^2$
1889.....	14.9	14.8					
1890.....	15.4	15.9	+0.5	+1.1	+0.55	0.25	1.21
1891.....	15.2	15.8	-0.2	-0.1	+0.02	0.04	0.01
1892.....	14.5	17.8	-0.7	+2.0	-1.40	0.49	4.00
1893.....	13.7	13.8	-0.8	-4.0	+3.20	0.64	16.00
1894.....	13.6	16.5	-0.1	+2.7	-0.27	0.01	7.29
1895.....	14.7	15.3	+1.1	-1.2	-1.32	1.21	1.44
1896.....	15.2	14.9	+0.5	-0.4	-0.20	0.25	0.16
1897.....	14.6	14.0	-0.6	-0.9	+0.54	0.36	0.81
1898.....	13.4	15.1	-1.2	+1.1	-1.32	1.44	1.21
1899.....	13.3	16.9	-0.1	+1.8	-0.18	0.01	3.24
1900.....	14.6	13.6	+1.3	-3.3	-4.29	1.69	10.89
1901.....	13.1	16.0	-1.5	+2.4	-3.60	2.25	5.76
1902.....	15.1	14.0	+2.0	-2.0	-4.00	4.00	4.00
1903.....	14.0	14.2	-1.1	+0.2	-0.22	1.21	0.04
1904.....	13.9	15.9	-0.1	+1.7	-0.17	0.01	2.89
1905.....	15.3	14.5	+1.4	-1.4	-1.96	1.96	1.96
1906.....	14.2	15.6	-1.1	+1.1	-1.21	1.21	1.21
1907.....	14.4	14.0	+0.2	-1.6	-0.32	0.04	2.56
1908.....	14.1	13.5	-0.3	-0.5	+0.15	0.09	0.25
1909.....	14.3	14.5	+0.2	+1.0	+0.20	0.04	1.00
1910.....	13.6	15.0	-0.7	+0.5	-0.35	0.49	0.25
1911.....	13.6	16.5	+0.0	+1.5	+0.00	0.00	2.25
1912.....	14.4	14.1	+0.8	-2.4	-1.92	0.64	5.76
1913.....	15.9	13.1	+1.5	-1.0	-1.50	2.25	1.00
1914.....	13.9	14.6	-2.0	+1.5	-3.00	4.00	2.25
Sum.....			-1.0	-0.2	-22.57	25.11	77.44

A glance at this table shows that in 25 cases we find 19 in which the signs are the reverse of each other and 6 in which they agree. Hence the probability of the opposition of the air temperatures at San Francisco and Erimo is 19/25ths, or 76 per cent. The correlation coefficient deduced from the above data is -0.51 and the probable error ± 0.102 . It may be therefore concluded that in July a temperature seesaw is fairly established on both sides of the North Pacific. When the July temperature at Erimo in northern Japan is higher than the average, the temperature at San Francisco in California is abnormally low, and vice versa.

2. Correlation between the April temperature at Irkutsk and the July temperature at San Francisco.—In the first note [M. W. R., January, 1916] of my researches on this subject I have traced a remarkable parallelism between the March barometric gradient at Zi-ka-wei near Shanghai and the July temperature on the east coast of northern Japan. This and the result given in the preceding paragraph induced me to search for an eventual correlation between the spring temperature on the Asiatic Continent and the summer temperature on the American coast of the North Pacific. After trials I have traced a marked opposition between the April temperature at Irkutsk in eastern Siberia and the air temperature at San Francisco for the following July. The temperature data for both stations are given in Table 3. The temperatures at Irkutsk have been taken from Annales de l'Observatoire

physique central Nicolas, the record beginning with 1887. Unfortunately the recent records are not within my reach. In the table z means the April temperature at Irkutsk and x the July temperature at San Francisco.

TABLE 3.—Correlation of April temperature at Irkutsk (z) and July temperature at San Francisco (x).

Year.	z	x	Departures.		$\Delta z \Delta x$	$(\Delta z)^2$	$(\Delta x)^2$
			Δz	Δx			
	° C.	° C.					
1887.....	1.7	13.7	+0.0	-0.7	-0.63	0.81	0.49
1888.....	-1.6	16.3	-2.4	+1.9	-4.56	5.76	3.61
1889.....	0.2	14.9	-0.6	+0.5	-0.30	0.36	0.25
1890.....	-0.3	15.4	-1.1	+1.0	-1.10	1.21	1.00
1891.....	-0.3	15.2	-1.1	+0.8	-0.88	1.21	0.64
1892.....	0.3	14.5	-0.5	+0.1	-0.05	0.25	0.01
1893.....	4.6	13.7	+3.8	-0.7	-2.66	14.44	0.49
1894.....	-0.8	13.6	-1.6	-0.8	+1.28	2.56	0.64
1895.....	2.0	14.7	+1.2	+0.3	+0.36	1.44	0.09
1896.....	1.4	15.2	+0.6	+0.8	+0.48	0.36	0.64
1897.....	1.0	14.6	+0.2	+0.2	+0.04	0.04	0.04
1898.....	1.9	13.4	+1.1	-1.0	-1.10	1.21	1.00
1899.....	3.9	13.3	+3.1	-1.1	-3.41	9.61	1.21
1900.....	-1.7	14.6	-2.5	+0.2	-0.50	6.25	0.04
1901.....	1.0	13.1	+0.2	-1.3	-0.26	0.04	1.69
1902.....	-0.8	15.1	-1.6	+0.7	-1.12	2.56	0.49
1903.....	0.6	14.0	-0.2	+0.4	+0.08	0.04	0.16
1904.....	-0.3	12.9	-1.1	-0.5	+0.55	1.21	0.25
1905.....	-1.5	15.3	-2.3	+0.9	-2.07	5.29	0.81
1906.....	4.5	14.2	+3.7	-0.2	-0.74	13.69	0.04
1907.....	1.9	14.4	+1.1	+0.0	0.00	1.21	0.00
Means.....	0.8	14.4					
Sums.....	17.7	93.1			16.59	68.34	13.59

$$r = \frac{16.59}{(68.34)^{\frac{1}{2}} (13.59)^{\frac{1}{2}}} = -0.53, \quad E = \pm 0.6745 \frac{(1-r^2)}{\sqrt{21}} = \pm 0.106.$$

Looking at the columns showing the departures from the normal it will be seen that the signs are opposite in 15 cases, and the same in 6 cases out of the 21 cases under consideration. The correlation coefficient deduced from the above data is -0.53 and the probable error ± 0.106 .

Hence we may conclude that when the April temperature at Irkutsk is higher than the normal we may expect with a high degree of probability that the temperature at San Francisco in the following July will be abnormally low, and vice versa.

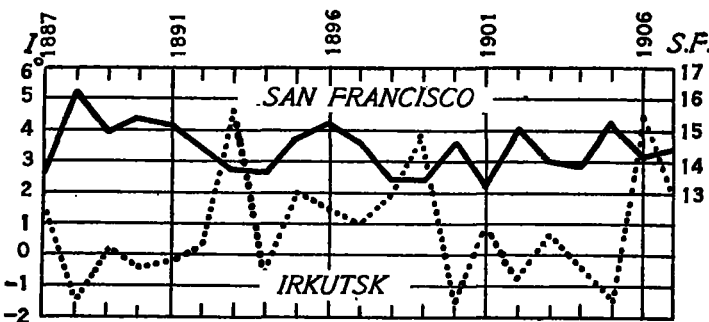


FIG. 2.—Graphic presentation of the opposition between the April temperature at Irkutsk and the temperature at San Francisco for the following July.

The above result will be of some interest on account of its bearing on the possibility of issuing a seasonal forecast on the Pacific coast of the United States, which Mr. A. G. McAdie³ has ardently advocated.

³ McAdie, A. G. Forecasting on the Pacific coast. MONTHLY WEATHER REVIEW, April, 1908, 36: 98-100.

³ Note by the Editor.—In the interest of clearness in notation the followingsystem has been adopted in this paper:

z = July temperatures at San Francisco, Cal.; Δz and δz = corresponding departures
 y = July temperatures at Erimo, Japan; Δy and δy = corresponding departures
 z = April temperatures at Irkutsk; Δz and δz = corresponding departures and deviations, respectively.
 w = January-February pressure at Zi-ka-wei; Δw and δw = corresponding departures and deviations, respectively.
 r = coefficient of correlation; E = probable error.

3. *Correlation between the winter barometric pressure at Zi-ka-wei near Shanghai and the summer barometric pressure at Nemuro in northern Japan.*—A marked opposition is traced between the barometric heights at Zi-ka-wei in January and February and those at Nemuro in July and August. We give below the barometric data for both stations. In this table *k* refers to Zi-ka-wei and *w* to Nemuro.

The last two columns contain the variations ($\delta k, \delta w$) of the barometric heights from year to year at both stations. The correlation coefficient deduced from these quantities is -0.41 . From the above results we may conclude that when the barometer stands higher than the average at Irkutsk in January and February we may expect that the pressure at Nemuro in the following July and August will be abnormally low.

TABLE 4.—Mean barometric pressures at Zi-ka-wei in January and February (*k*) and at Nemuro in July and August (*w*).

Year.	<i>k</i>	<i>w</i>	Δk	Δw	$\Delta k \Delta w$	$(\Delta k)^2$	$(\Delta w)^2$	Annual variations.	
								δk	δw
	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.	mm.
1886.....	770.3	758.4	+1.2	+0.2	+0.24	1.44	0.04	.....	.....
1887.....	769.0	758.4	-0.1	+0.2	-0.02	0.01	0.04	-0.7	+0.0
1888.....	769.4	756.6	+0.3	-1.6	-0.46	0.09	2.56	+0.4	-1.8
1889.....	770.4	757.4	+1.3	-0.8	-1.04	1.69	0.64	+1.0	+0.8
1890.....	768.1	759.2	-1.0	+1.0	-1.00	1.00	1.00	-2.3	+1.8
1891.....	769.3	757.4	+0.2	-0.8	-0.16	0.04	0.64	+1.2	-1.8
1892.....	768.6	757.9	-0.5	-0.3	+0.15	0.25	0.09	-0.7	+0.5
1893.....	769.7	757.8	+0.6	-0.4	-0.24	0.36	0.16	+1.1	-0.1
1894.....	769.1	756.6	± 0.0	-1.6	0.00	0.00	2.56	-0.6	-1.2
1895.....	768.1	758.8	-1.0	+0.6	-0.60	1.00	0.36	-1.0	+2.2
1896.....	769.4	758.3	+0.3	+0.1	+0.03	0.09	0.01	+1.3	-0.5
1897.....	769.3	758.2	+0.2	± 0.0	0.00	0.04	0.00	-0.1	-0.1
1898.....	767.3	757.8	-1.8	-0.4	+0.72	3.24	0.16	-2.0	-0.4
1899.....	769.0	757.8	-0.1	-0.4	+0.04	0.01	0.16	+1.7	± 0.0
1900.....	770.4	757.0	+1.3	-1.2	-1.56	1.69	1.44	+1.4	-0.8
1901.....	769.9	758.2	+0.8	± 0.0	0.00	0.64	0.00	-0.5	+1.2
1902.....	769.7	759.0	+0.6	+0.8	+0.48	0.36	0.64	-0.2	+0.8
1903.....	770.6	757.7	+1.5	-0.5	-0.75	2.25	0.25	+0.9	-1.3
1904.....	769.3	758.5	+0.2	+0.3	+0.06	0.04	0.09	-1.3	+0.8
1905.....	767.3	758.9	-1.8	+0.7	-1.26	3.24	0.49	-2.0	+0.4
1906.....	767.9	758.3	-1.2	+0.1	-0.12	1.44	0.01	+0.6	-0.6
1907.....	769.3	758.7	+0.2	+0.5	+0.10	0.04	0.25	+1.4	+0.4
1908.....	769.8	758.8	+0.7	+0.6	+0.42	0.49	0.36	+0.5	+0.1
1909.....	768.5	759.1	-0.6	+0.9	-0.54	0.36	0.81	-0.4	+0.3
1910.....	768.3	759.8	-0.8	+1.6	-1.28	0.64	2.56	-0.2	+0.7
Sums.....	.....	.....	.....	.....	-7.19	20.45	15.32	.....	.....
Means....	769.1	758.2	.....	.....	.....	.....	.....	.....	.....

$$r = -\frac{7.19}{(20.45)^{\frac{1}{2}} \wedge (15.32)^{\frac{1}{2}}} = -0.41; \quad E = \pm 0.6745 \frac{(1-r^2)}{\sqrt{n}} = \pm 0.112.$$